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FINAL REPORT
FOR

JANTX1N5622

FEBRUARY 1979

Prepared
For

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FOREWORD

This report is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short-term objective of this preliminary study of transistors, diodes, and FETS is to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long-term objective is to gain more knowledge of accelerated stress testing for use in future testing of discrete devices, as well as to determine which type of stress should be applied to a particular device or design.

This report is divided as follows: description of tests, figures, tables, and appendix.



TABLE OF CONTENTS

	<u>Page</u>
1.0 INTRODUCTION	1
2.0 TEST REQUIREMENTS	1
2.1 Electrical	1
2.2 Stress Circuit	1
2.3 Group I - Power Stress	2
2.4 Group II - Temperature Stress I	2
2.5 Group III - Temperature Stress II	2
3.0 DISCUSSION OF TEST RESULTS	3
3.1 Group I - Power Stress	3
3.1.1 Semtech	3
3.1.2 Micro Semiconductor	3
3.1.3 Statistical Summary - Group I	4
3.2 Group II - Temperature Stress I	4
3.2.1 Semtech	4
3.2.2 Micro Semiconductor	5
3.2.3 Statistical Summary - Group II	6
3.3 Group III - Temperature Stress II	6
3.3.1 Semtech	6
3.3.2 Micro Semiconductor	7
3.3.3 Statistical Summary - Group III	7
4.0 FINAL DATA SUMMARY	7
5.0 CONCLUSIONS	8
APPENDIX A	26
APPENDIX B	31
APPENDIX C	35



LIST OF ILLUSTRATIONS

<u>Figure</u>	<u>Title</u>	<u>Page</u>
1	Power and Temperature Stress Circuit for JANTX1N5622	11
2	Cumulative Percent Failures Versus Junction Temperature, Semtech	12
3	Time Steps Versus Junction Temperature, Semtech	13
4	Cumulative Percent Failures Versus Junction Temperature, Micro Semiconductor	14
5	Time Steps Versus Junction Temperature, Micro Semiconductor	15
A-1	S/N 6417. Magnification 13X	29
A-2	S/N 6443. Magnification 10X	29
A-3	S/N 6449. Magnification 15X	30
B-1	S/N 6425. Magnification 11X	33
B-2	S/N 6468. Magnification 13X	33
C-1	S/N 02. Magnification 10X	38
C-2	S/N 04. Magnification 11X	38
C-3	S/N 6488. Magnification 10X	39



LIST OF TABLES

<u>Table</u>	<u>Title</u>	<u>Page</u>
1	Test Flow Diagram	16
2	Parameters and Test Conditions	17
3	Power Stress Burn-In Conditions	17
4	Group I - Power Stress Data Summary	19
5	Group II - Temperature Stress I Data Summary	21
6	Group III - Temperature Stress II Data Summary	22
7	Final Data Summary	23
8	Step Stress Catastrophic Failure Summary	24
9	Step Stress Parametric Failure Summary	25



1.0 INTRODUCTION

DCA Reliability Laboratory, under Contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of semiconductor devices. This report covers the diode JANTX1N5622 manufactured by Semtech and Micro Semiconductor.

A total of 48 samples from each manufacturer was submitted to the process outlined in Table 1. In addition, two control sample units were maintained for verification of the electrical parametric testing.

2.0 TEST REQUIREMENTS

2.1 Electrical

All test samples were subjected to the electrical tests outlined in Table 2 after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 High-Speed Computer-Controlled Tester. Additional bench testing was also required on the devices.

2.2 Stress Circuit

The test circuit shown in Figure 1 was used to power all the test devices during the power/temperature stress conditions. The voltage was set by V_F and the current was varied in order to comply with the specified power rating for the device. At least one of the devices was subjected to maximum rated power (MRP). All remaining devices were



subjected to no less than 90% of MRP. See Figure 1 for load resistance values and voltages.

2.3 Group I - Power Stress

Thirty-two units, 16 from each manufacturer, were submitted to the Power Stress Process. The diodes were stressed in 500-hour steps at 50, 100, 125, 150 and 175 percent of maximum rated power (MRP) for 2500 hours or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each power step. See Table 1. (*See Notes at end of text.)

2.4 Group II - Temperature Stress I

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress I Process. Group II was subjected to 1600 hours of stress at maximum rated power in increments of 160 hours. The temperature was increased in steps of 25°C, commencing at 75°C and terminating at 300°C or until 50% or more of the devices failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

2.5 Group III - Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress II Process. Group III was subjected to 112 hours of stress at maximum rated power in increments of 16 hours. The temperature was increased in steps of 25°C, commencing at 150°C and terminating at 300°C or until 50% or more of the devices in a sample lot



failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

3.0 DISCUSSION OF TEST RESULTS

3.1 Group I - Power Stress

3.1.1 Semtech. The Semtech sample lot completed 1250 hours of Group I Testing before it was stopped because of seven catastrophic and one MIL-S-19500 failure. The first failures occurred 150 hours into the 125% MRP step. Serial number 6418 failed due to excessive I_R leakage. Serial number 6419 was removed as a MIL-S-19500 failure. The last failures occurred 250 hours into the 125% MRP step. Serial numbers 6413, 6415, 6416, 6417 and 6420 failed due to excessive I_R leakage. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 3.217mA from an initial mean of 95.76nA to a final mean of 3.217mA.
- 2) The mean value for V_F changed 10.00mV from an initial mean of 1.173V to a final mean of 1.163V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.2 Micro Semiconductor. The Micro Semiconductor sample lot completed 1525 hours of Group I Testing before it was stopped with seven catastrophic failures. At 150 hours into the 125% MRP step, serial number 6446 was removed from testing. The



first catastrophic failure occurred 250 hours into the 125% MRP step. Serial number 6444 failed due to excessive I_R leakage. The next failures occurred 500 hours into the 125% MRP step. Serial numbers 6443 and 6449 failed due to excessive I_R leakage. The next failures occurred 10 hours into the 150% MRP step. Serial numbers 6445 and 6455 failed due to excessive I_R leakage. The next failures occurred 25 hours into the 150% MRP step. Serial numbers 6447 and 6452 failed due to excessive IR leakage. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 1.087mA from an initial mean of 16.40nA to a final mean of 1.087mA.
- 2) The mean value for V_F changed 69.00mV from an initial mean of 1.066V to a final mean of 1.135V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.3 Statistical Summary - Group I. Table 4 outlines the results of Group I - Power Stress Process for each of the electrical parameters and all measurement points for both Semtech and Micro Semiconductor.

3.2 Group II - Temperature Stress I

3.2.1 Semtech. The Semtech sample lot completed 640 hours of Group II Testing before being stopped because 50% of lot had failed. At 160 hours into the 75°C-temperature step, serial number 6397 was missing from the test lot. The first failures



occurred 160 hours into the 125°C-temperature step. Serial numbers 6423 and 6425 failed due to excessive I_R leakage. The last failures occurred 160 hours into the 150°C-temperature step. Serial numbers 6421, 6422, 6424, 6426, 6427 and 6428 failed due to excessive I_R leakage. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 4.611mA from an initial mean of 82.34nA to a final mean of 4.611mA.
- 2) The mean value for V_F changed 8.000mV from an initial mean of 1.174V to a final mean of 1.166V.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.2 Micro Semiconductor. The MSC sample lot completed 800 hours of Group II Testing before being stopped because more than 50% of the lot failed. The first failure occurred 160 hours into the 125°C-temperature step. Serial number 6468 failed due to excessive I_R leakage. The next failures occurred 160 hours into the 150°C-temperature step. Serial number 6461 was removed as a visual catastrophic failure. (See Note B on Table 8 - Step Stress Catastrophic Failure Summary.) Serial numbers 6470, 6471 and 6474 failed because of excessive I_R leakage. The last failures occurred 160 hours into the 175°C-temperature step. Serial numbers 6459, 6465, 6467 and 6475 failed due to excessive I_R leakage. Serial number 6463 was removed as a visual catastrophic failure. (See Note C, Table 8.) Typical characteristics of this



sample lot's performance were:

- 1) The mean value for I_R changed 268.4 μ A from an initial mean of 43.30nA to a final mean of 268.4 μ A.
- 2) The mean value for V_F changed 25.00mV from an initial mean of 1.084V to a final mean of 1.109V.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.3 Statistical Summary - Group II. Table 5 of this report outlines the results of Group II - Temperature Stress I Testing, for each of the electrical parameters and all of the measurement points pertaining to both Semtech and Micro Semiconductor.

3.3 Group III - Temperature Stress II

3.3.1 Semtech. The Semtech sample lot completed 32 hours of Group III Testing at which time 50% of the lot had failed. The lot continued processing another 16 hours with no additional failures. The first failures occurred 16 hours into the 150°C-temperature step. Serial numbers 6431, 6433, 6434, 6435 and 6436 failed due to excessive I_R leakage. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 4.995mA from an initial mean of 81.10nA to a final mean of 4.995mA.
- 2) The mean value for V_F changed 10.00mV from an initial mean of 1.168V to a final mean of 1.158V.



3.3.2 Micro Semiconductor. The MSC sample lot completed 64 hours of Group III Testing before it was stopped with seven catastrophic failures. The first failures occurred 16 hours into the 200°C-temperature step. Serial numbers 6475 and 6483 failed due to excessive I_R leakage. The last failures occurred 16 hours into the 225°C-temperature step. Serial numbers 6477, 6484, 6488 and 6490 failed due to excessive I_R leakage. Serial number 6488 was removed as a visual catastrophic reject. (See Note C, Table 8.) Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 1.579mA from an initial mean of 43.33nA to a final mean of 1.579mA.
- 2) The mean value for V_F changed 12.00mV from an initial mean of 1.073V to a final mean of 1.061V.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.3 Statistical Summary - Group III. Table 6 outlines the results of Group III - Temperature Stress II Testing, for each of the electrical parameters and all of the measurement points for both Semtech and Micro Semiconductor.

4.0 FINAL DATA SUMMARY

Table 7 statistically summarizes the change in the mean value from the zero-hour data to the final data. The graphs of Figures 2 and 4 plot the cumulative percent failures versus the temperature stress level for Group II - Temperature Stress I,



and Group III - Temperature Stress II. The graphs of Figures 3 and 5 plot the time step for Group II (160 hours) and Group III (16 hours) versus the temperatures T_1 and T_2 calculated from Figures 2 and 4. Tables 8 and 9 summarize the failures encountered for all three stress groups. The failures are separated into two categories: catastrophic failures in Table 8 and parametric failures in Table 9. The data from Table 8 were used as a source for the graphs in Figures 2 and 4. Figures 2 and 4 were used as a source for the graphs in Figures 3 and 5, respectively. Junction temperature is plotted on an inverse hyperbolic scale.

5.0

CONCLUSIONS

All three tests proved to be detrimental to the diodes from both Semtech and Micro Semiconductor. All six sample lots were halted before the testing process had been completed. However, in each case the MSC proceeded longer than the Semtech lot.

The failure mode of the three Semtech lots was excessive reverse bias leakage. Failure analysis revealed this to be due to the development of excessive conductivity in the external paint. When the conductivity of the paint was interrupted by sanding, the reverse leakage fell to acceptable levels.

The MSC Group I diodes also had a failure mode of excessive I_R leakage. Failure analysis showed that this was caused by damaged silicon induced by the stress test. The analyzed diodes still show a



characteristic forward breakdown curve, indicating that they are not totally destroyed, but have resistive pathways (damage sites) in parallel with the junctions.

The failure modes in Group II and III Testing of MSC were loss of leads due to the melting of connecting metal and cracked and broken glass. The excessive glass breakage is due to residual glass strain which was not annealed out. The strain can be seen under polarized light.

A plot showing cumulative failure distribution for Groups II and III was drawn for the Micro Semiconductor sample lot (Figures 4 and 5), but due to an absence of main Group III failure points, only Group II could be completely drawn for the Semtech sample lot (Figures 2 and 3). Figures 4 and 5 display the data for the MSC sample lot used to calculate an activation energy of 1.13eV.

A broken circle around a marked point on the graph indicates a freak failure not calculated as part of the regression line. A solid circle around a marked point indicates an isolated mean failure point. The regression line was calculated using the least squares method.



The activation energy was calculated from the formula:

$$E = \left[\ln \left(\frac{t_1}{t_2} \right) \right] \left[\frac{8.63 \times 10^{-5} \text{ eV/}^\circ\text{K}}{\left(\frac{1}{T_1 + 273} \right) - \left(\frac{1}{T_2 + 273} \right)} \right] \text{ eV}$$

Where: t_1 = step of Group II - Temp Stress I = 160 hrs.

t_2 = step of Group III - Temp Stress II = 16 hrs.

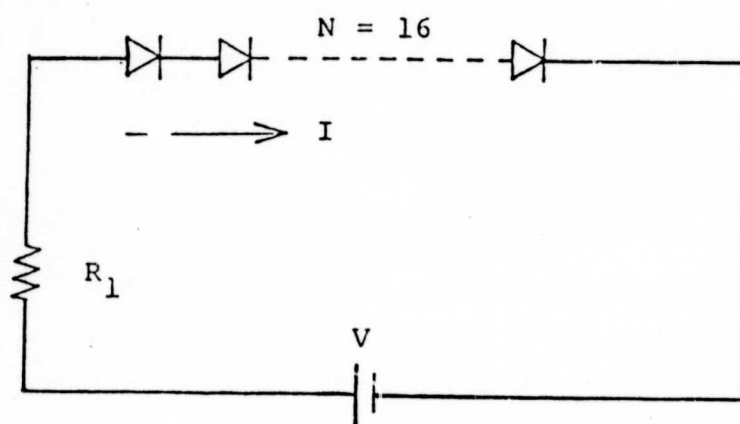
T_1 = temperature in $^\circ\text{C}$ of 16% failure for Group II.

T_2 = temperature in $^\circ\text{C}$ of 16% failure for Group III.

NOTE:

* Conditions for failure:

- A) Open or short
- B) Leakage exceeds the maximum limit by 100 times
- C) Other parameters exceed MIL limits by 50% or more.

SWITCHING DIODES

$$R_1 = 1V/I \pm 1\%$$

$$P_d = IE$$

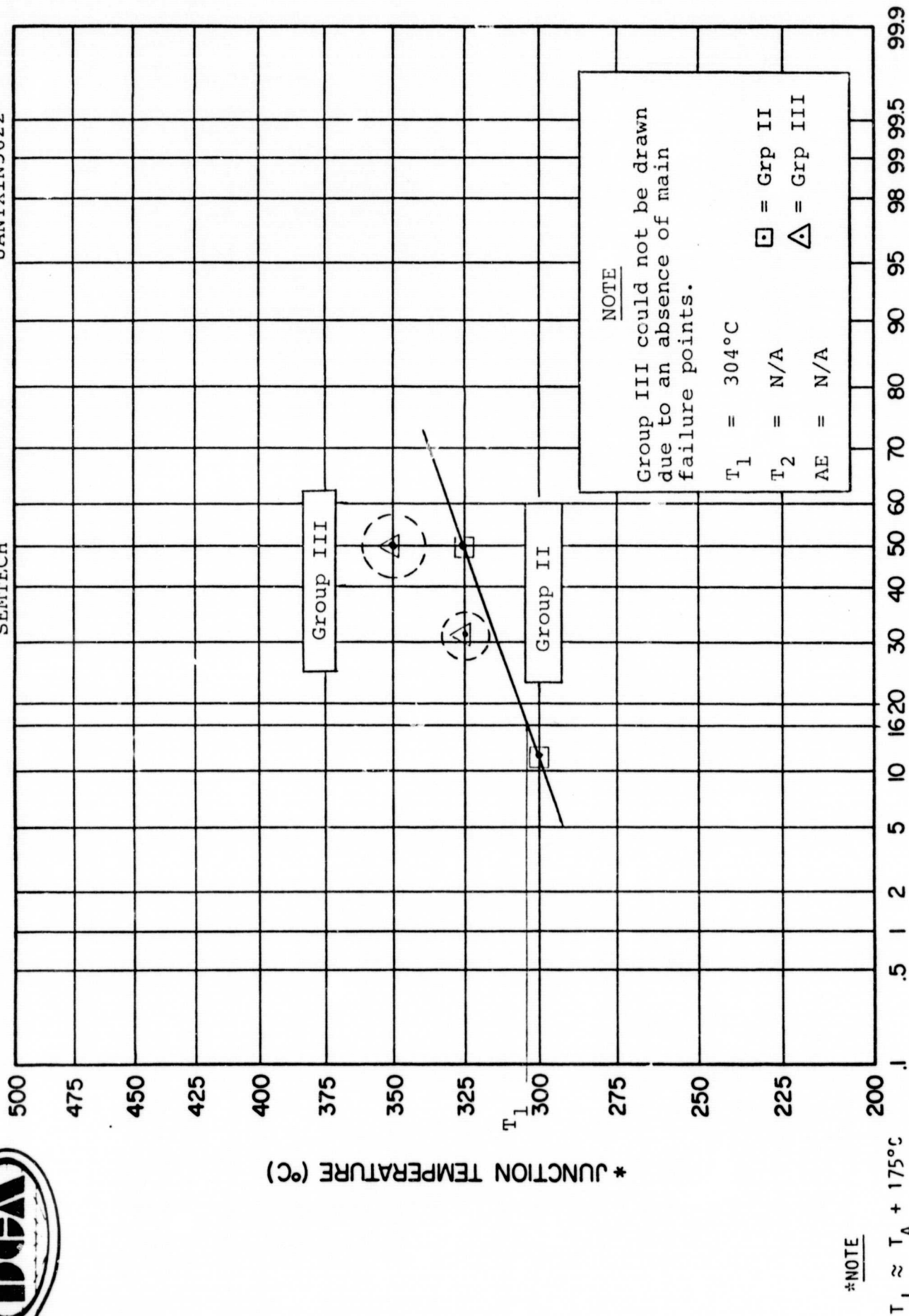
FIGURE 1
Power/Temperature Stress Circuit
for JANTX1N5622



SEMTECH

JANTX1N5622

JANTX1N5622



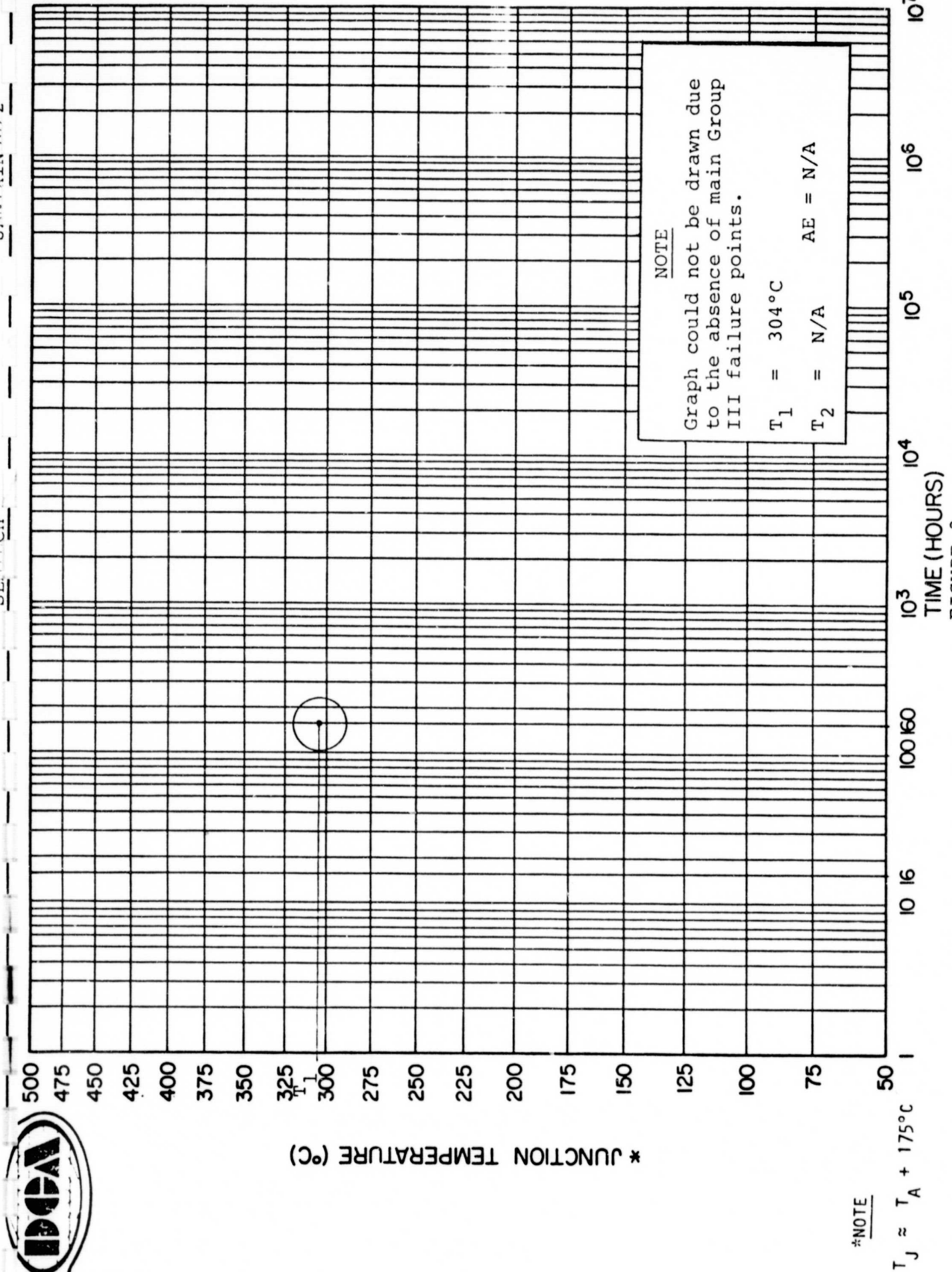
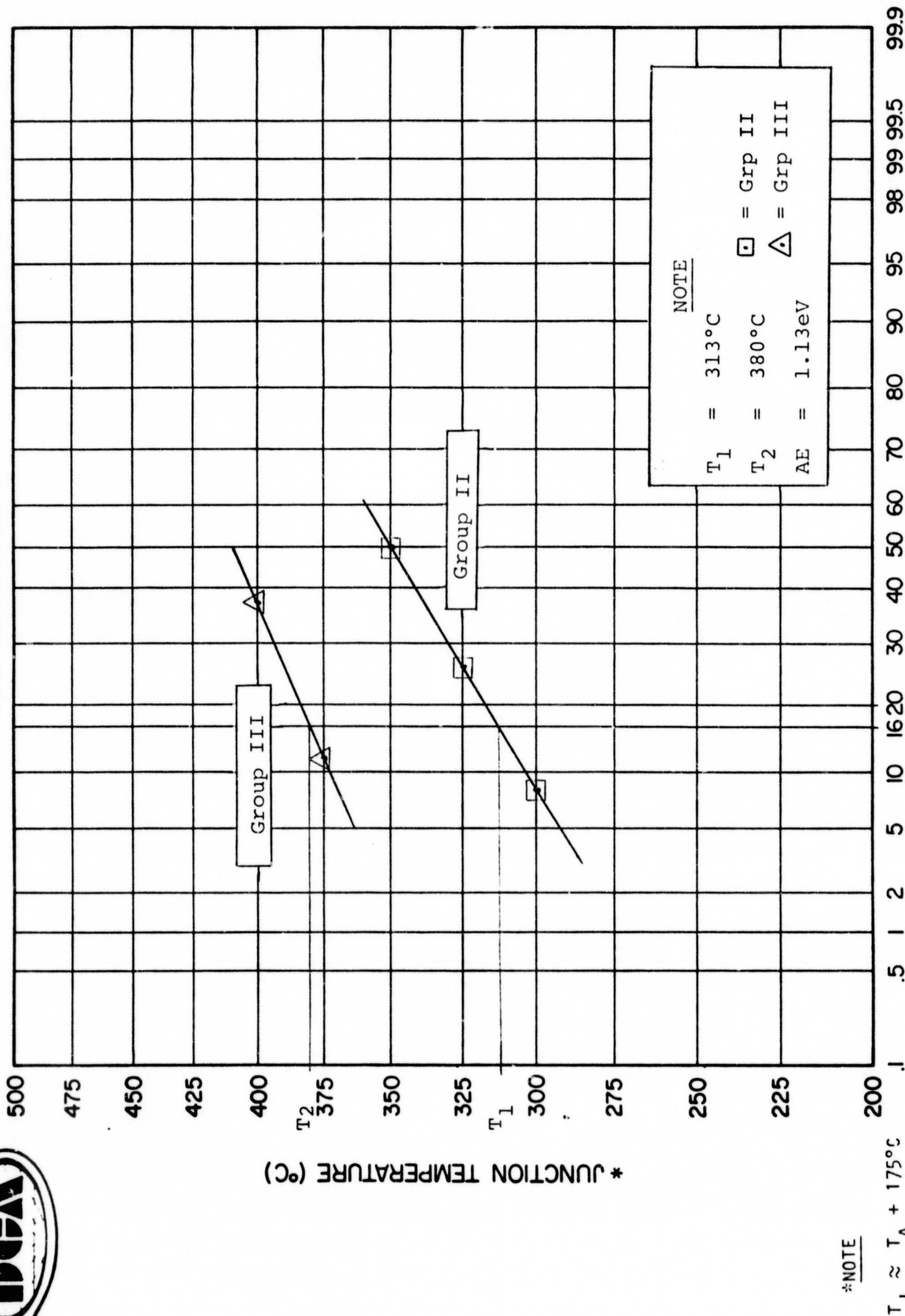


FIGURE 3
Time Steps Versus Junction Temperature, Semtech



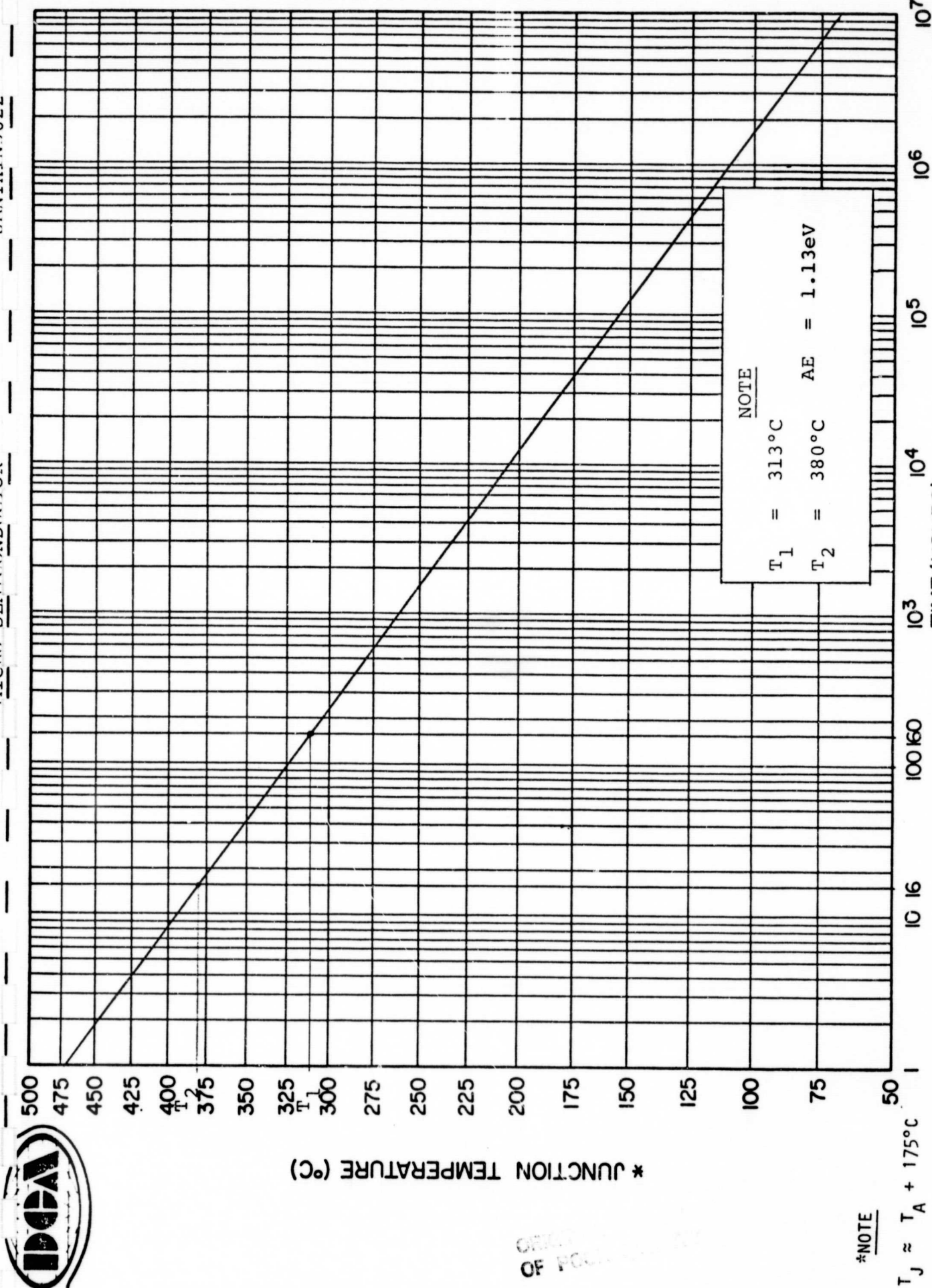
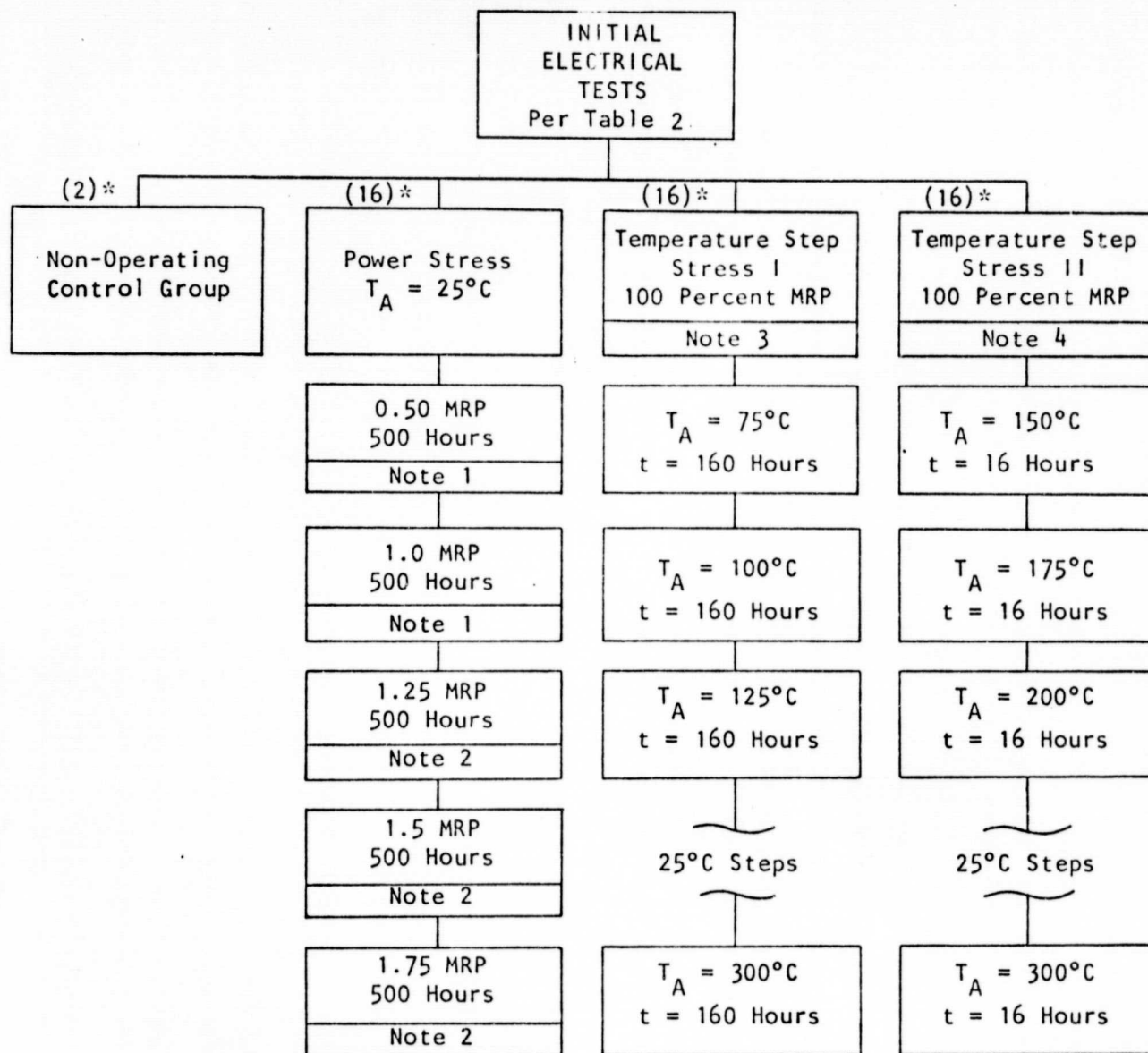


FIGURE 5
Time Steps Versus Junction Temperature, Micro Semiconductor

TABLE 1
TEST FLOW DIAGRAM

*Quantity per manufacturer (Semtech and Micro Semiconductor)

NOTES:

- 1) Electrical measurements per Table 2 were made at 50, 150, 250 and 500 hours.
- 2) Electrical measurements per Table 2 were made at 10, 25, 50, 150, 250 and 500 hours.
- 3) Electrical measurements per Table 2 were made at the end of each 160 hours.
- 4) Electrical measurements per Table 2 were made at the end of each 16 hours.

TABLE 2
PARAMETERS AND TEST CONDITIONS

PARAMETER	CONDITIONS	SPEC. LIMIT		CAT. LIMIT		UNITS
		MIN	MAX	MIN	MAX	
I_R	$V_R = 1000V$	-	.5		50	μA
V_F	$I_F = 3.0A$ (Pulsed)	0.8	1.3	0.4	1.95	V(PK)

NOTES:

1/ In addition, any open or short shall be considered catastrophic.

TABLE 3
POWER STRESS BURN-IN CONDITIONS

$V_F = 1V$	
I_F	Percent P_D
0.6A	50
1.2A	100
1.5A	125
1.8A	150
2.1A	175



NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of $\pm 1\%$ of the reading and $\pm$ one digit except for readings greater than 9.99mA which have an absolute accuracy of $\pm 2\%$ of the reading and $\pm$ one digit. The data also have a resolution for four digits. The standard deviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.

TABLE 4
GROUP I - POWER STRESS DATA SUMMARY

Page 1 of 2

PARAMETER	$I_R = .5\mu A$	$V_F = .08V(PK)(MIN)$ $1.3V(PK)(MAX)$		
CONDITIONS AND LIMIT	$V_R = 1000V$	$I_F = 3.0A (Pulsed)$		
IDENTIFICATION	SEM	MSC	SEM	MSC
INITIAL DATA				
MIN VALUE	29.10nA	3.820nA	1.100V	998.0mV
MAX VALUE	363.0nA	93.50nA	1.230V	1.160V
MEAN	95.76nA	16.40nA	1.173V	1.066V
STD DEV	78.41nA	21.70nA	34.41mV	42.85mV
INTERIM DATA				
POWER 50 TO 125% Δ MEAN VALUE				
50% POWER				
50 HRS	34.54nA	2.870nA	5.000mV	-1.000mV
150 HRS	33.14nA	2.800nA	0.000V	-4.000mV
250 HRS	35.04nA	2.440nA	-6.000mV	4.000mV
500 HRS	29.94nA	2.030nA	2.000mV	-2.000mV
100% POWER				
550 HRS	11.34nA	1.330nA	-28.00mV	-10.00mV
650 HRS	-1.170nA	-1.240nA	3.000mV	-10.00mV
750 HRS	2.850nA	-3.600nA	5.000mV	7.000mV
1000 HRS	-2.890nA	-3.450nA	-2.000mV	5.000mV
125% POWER				
1010 HRS	1.860nA	240.0pA	0.000V	-4.000mV
1025 HRS	10.34nA	-1.770nA	-4.000mV	3.000mV
1050 HRS	12.14nA	-2.260nA	3.000mV	1.000mV
1150 HRS	*9.800pA	-580.0pA	-3.000mV	-1.000mV
1250 HRS	*3.217mA	*52.45pA	-10.00mV	-5.000mV
1500 HRS	JOB STOPPED	*923.9pA	JOB STOPPED	-9.000mV

(continued on second sheet)

TABLE 4 (Cont'd)
— POWER STRESS DATA SUMMARY

Page 2 of 2

(continued from first sheet)

GROUP I

PARAMETER	$I_R = .5\mu A (MAX)$		$V_F = .08V (PK) (MIN)$ $1.3V (PK) (MAX)$			
CONDITIONS AND LIMITS	$V_R = 1000V$		$I_F = 3.0A (Pulsed)$			
IDENTIFICATION	SEM	MSC	SEM	MSC		
INITIAL DATA						
MIN VALUE	29.10nA	3.820nA	1.100V	998.0mV		
MAX VALUE	363.0nA	93.50nA	1.230V	1.160V		
MEAN	95.76nA	16.40nA	1.173V	1.066V		
STD DEV	78.41nA	21.70nA	34.41mV	42.85mV		
INTERIM DATA						
POWER 150 TO 175% Δ MEAN VALUE						
150% POWER						
1510 HRS				51.00mV		
1525 HRS				69.00mV		
1550 HRS		*873.2 μA *1.087mA JOB STOPPED		JOB STOPPED		
1650 HRS						
1750 HRS						
2000 HRS						
175% POWER						
2010 HRS						
2025 HRS						
2050 HRS						
2150 HRS						
2250 HRS						
2500 HRS						
FINAL DATA						
MIN VALUE	40.70nA	3.730nA	1.090V	1.040V		
MAX VALUE	9.990mA	9.990mA	1.230V	1.720V		
MEAN	3.217mA	1.087mA	1.163V	1.135V		
STD DEV	4.243mA	2.979mA	36.23mV	198.0mV		

* NOTE: Catastrophic reject(s) removed from data after this point

TABLE 5
GROUP II TEMP STRESS I DATA SUMMARY

PARAMETERS	$I_R = .5\mu A (MAX)$		$V_F = .08V (PK) (MIN)$ $I_F = 3.0A (PK) (MAX)$			
CONDITIONS AND LIMITS	$V_R = 1000V$		$I_F = 3.0A (Pulsed)$			
IDENTIFICATION	SEM	MSC	SEM	MSC		
INITIAL DATA						
MIN VALUE	47.30nA	3.130nA	1.110V	999.0mV		
MAX VALUE	198.0nA	149.0nA	1.270V	1.270V		
MEAN	82.34nA	43.30nA	1.174V	1.084V		
STD DEV	46.70nA	47.66nA	54.07mV	56.65mV		
INTERIM DATA (INITIAL TO FINAL)						
Δ MEAN VALUE						
TOTAL HRS. TEMP (T_A)						
160 75°C						
320 100°C						
480 125°C						
640 150°C						
800 175°C						
960 200°C						
1020 225°C						
1280 250°C						
1440 275°C						
1600 300°C						
	-3.620nA -6.400nA *55.18μA *4.611mA JOB STOPPED	-1.220nA -1.090nA *56.51μA *232.8μA *268.4μA JOB STOPPED	9.000mV 11.00mV 17.00mV -8.000mV JOB STOPPED	5.000mV 8.000mV 11.00mV 12.00mV 25.00mV JOB STOPPED		
FINAL DATA						
FINAL TEMP (T_A)	150°C	175°C	150°C	175°C		
MIN VALUE	38.90nA	4.500nA	1.120V	1.050V		
MAX VALUE	9.990mA	1.090mA	1.290V	1.280V		
MEAN	4.611mA	268.4μA	1.166V	1.109V		
STD DEV	4.980mA	419.5μA	44.47mV	64.41mV		

* NOTE: Catastrophic reject(s) removed from data after this point

JANTXIN5622

TABLE 6
GROUP III TEMP STRESS II DATA SUMMARY

PARAMETERS	$I_R = .5\mu A(\text{MAX})$		$V_F = .08V(\text{PK}) (\text{MIN})$ $I_F = 3.0A (\text{Pulsed})$		$V_F = .08V(\text{PK}) (\text{MIN})$ $I_F = 3.0A (\text{Pulsed})$	
CONDITIONS AND LIMITS	$V_R = 1000V$		$I_F = 3.0A (\text{Pulsed})$		$I_F = 3.0A (\text{Pulsed})$	
IDENTIFICATION	SEM	MSC	SEM	MSC	SEM	MSC
INITIAL DATA						
MIN VALUE	30.80nA	6.040nA	1.100V	1.040V	1.100V	1.040V
MAX VALUE	163.0nA	234.0nA	1.260V	1.190V	1.260V	1.190V
MEAN	81.10nA	43.33nA	1.168V	1.073V	1.168V	1.073V
STD DEV	43.24nA	67.37nA	41.87mV	35.83mV	41.87mV	35.83mV
INTERIM DATA (INITIAL TO FINAL)						
Δ MEAN VALUE						
TOTAL HRS						
TEMP (T_A)						
16 150°C	*226.8 μA	-9.660nA	3.000mV	5.000mV	3.000mV	5.000mV
32 175°C	*603.6 μA	260.0pA	0.000V	0.000V	0.000V	0.000V
48 200°C	4.995mA	*149.3 μA	-10.00mV	5.000mV	5.000mV	5.000mV
64 225°C	JOB STOPPED	*1.579mA	JOB STOPPED	-12.00mV	-12.00mV	-12.00mV
80 250°C	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED
96 275°C	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED
112 300°C	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED
FINAL DATA						
FINAL TEMP (T_A)	200°C	225°C	200°C	225°C	200°C	225°C
MIN VALUE	60.30nA	3.950nA	1.110V	1.040V	1.110V	1.040V
MAX VALUE	9.990mA	9.990mA	1.210V	1.100V	1.210V	1.100V
MEAN	4.995mA	1.579mA	1.158V	1.061V	1.158V	1.061V
STD DEV	4.995mA	3.455mA	27.21mV	19.22mV	27.21mV	19.22mV

* NOTE: Catastrophic reject(s) removed from data after this point



JANTX1N5622

TABLE 7
FINAL DATA SUMMARY

PARAMETER	SPECIFICATIONS LIMIT		U N I T S	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE					
					POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II	
	MIN	MAX			SEM	MSC	SEM	MSC	SEM	MSC
I _R	-	.5	μA		*+248.23	*+183.53	*+1166.5	*+111.54	*+1941.8	*+432.07
V _F	0.8	1.3	V		-.00269	+ .00588	+ .00725	+ .01220	-.00233	-.00050

* NOTE: Catastrophic reject(s) removed from data

JANTX1N5622



TABLE 8 STEP STRESS

CATASTROPHIC

FAILURE SUMMARY

JAN TX1N5622

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
125% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	1	A	0	-
100 hr.	6	A	1	A
250 hr.	JOB STOPPED		2	A
150% 10 hr.			2	A
15 hr.			2	A
25 hr.			JOB STOPPED	
100 hr.				
100 hr.				
250 hr.				
175% 10 hr.				
15 hr.				
25 hr.				
100 hr.				
100 hr.				
250 hr.				

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T _A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75°C	0	-	0	-
100°C	0	-	0	-
125°C	2	A	1	A
150°C	6	A	1 3	B A
175°C	JOB STOPPED		1 4	C A
200°C			JOB STOPPED	
225°C				
250°C				
275°C				
300°C				

NOTES: A - I_R > 50μA

B - Visual reject - diode cracked in half

C - Visual reject - external lead disconnected due to stress

D - Shorted (verified by failure analysis)

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T _A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	2 3	A D	0	-
175°C	3	A	0	-
200°C	0	-	2	A
225°C	JOB STOPPED		4 1	A C
250°C			JOB STOPPED	
275°C				
300°C				

MFR "A" - SEMTECH

MFR "B" - MICRO SEMICONDUCTOR

JANTX1N5622



TABLE 9 STEP STRESS

PARAMETRIC

FAILURE SUMMARY

JAN TX1N5622

JANTX1N5622

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
125% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	3	A B	1	C
100 hr.	0	-	1	A
250 hr.	JOB STOPPED		0	-
150% 10 hr.			0	-
15 hr.			0	-
25 hr.			JOB STOPPED	
100 hr.				
100 hr.				
250 hr.				
175% 10 hr.				
15 hr.				
25 hr.				
100 hr.				
100 hr.				
250 hr.				

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T _A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75°C	1	D	0	-
100°C	0	-	0	-
125°C	5	A	0	-
150°C	0	-	1	A
175°C	JOB STOPPED		0	-
200°C			JOB STOPPED	
225°C				
250°C				
275°C				
300°C				

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T _A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	3	-	0	-
175°C	0	-	0	-
200°C	0	-	0	-
225°C	JOB STOPPED		0	-
250°C			JOB STOPPED	
275°C				
300°C				

MFR "A" - SEMTECH

MFR "B" - MICRO SEMICONDUCTOR

NOTES: A - I_R limit failure

B - S/N 6419 removed from testing as MIL-S-19500 failure

C - S/N 6446 removed from testing

D - S/N 6397 missing from testing



JANTX1N5622

APPENDIX A

FAILURE ANALYSIS

POWER STRESS



JANTX1N5622

FAILURE ANALYSIS

Date 18 December 1978

J/N 2CN242-26A P/N 1N5622 MFR SEMTECH

Cat. Limit:
50 μ A Max.Cat. Limits:
0.4-1.95 V.

S/N	PIV -volts0	I_R @ 1000 V.dc	V_F @ 3.0A dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
6417 Paint off:	R >1100	>2.0mA 100nA	1.14	27 (125% MRP 1250 Hrs.)	I_R
6418 Paint off:	R >1100	>2.0mA 100nA	1.22	25 (125% MRP 1150 Hrs.)	I_R
6420 Paint off:	R >1100	1.4mA 100nA	1.21	27 (125% MRP 1250 Hrs.)	I_R

VISUAL INSPECTION

There are no significant visual defects on these Semtech diodes (see Figure A-1).

CONCLUSION

These Semtech diodes failed I_R because of conductive external paint. They became entirely acceptable when the continuity of the paint was broken by sanding a gap in the paint all around the diodes. (See measurements above.)

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* h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
** h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable



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JANTX1N5622

FAILURE ANALYSIS

Date 18 December 1978

J/N 2CN242-26A P/N 1N5622 MFR MICRO SEMICONDUCTOR

Cat. Limit:
50 A Max.

Cat. Limits:
0.4-1.95V

S/N	PIV -volts-	I_R @ 1000 V.dc	V_F @ 3.0 A dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
6443	R	>2.0mA	---	29 (125% MRP 1500 Hrs.)	I_R
6449	800 → R SNAP	>2.0mA	1.10	29 (125% MRP 1500 Hrs.)	I_R
6452	R	>2.0mA	1.80	33 (150% MRP 1525 Hrs.)	I_R

VISUAL INSPECTION

All three Micro Semiconductor diodes were cracked. S/N 6443 had a large chip out at one end, and two cracks. It fell apart while being handled (see Figures A-2, A-3 and A-4).

CONCLUSION

These Micro Semiconductor diodes failed I_R because of silicon damage induced by the MSFC test. The diodes still have a characteristic forward breakdown curve, indicating that they are not totally destroyed, but have resistive pathways (damage sites) in parallel with the junction.

* h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
** h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

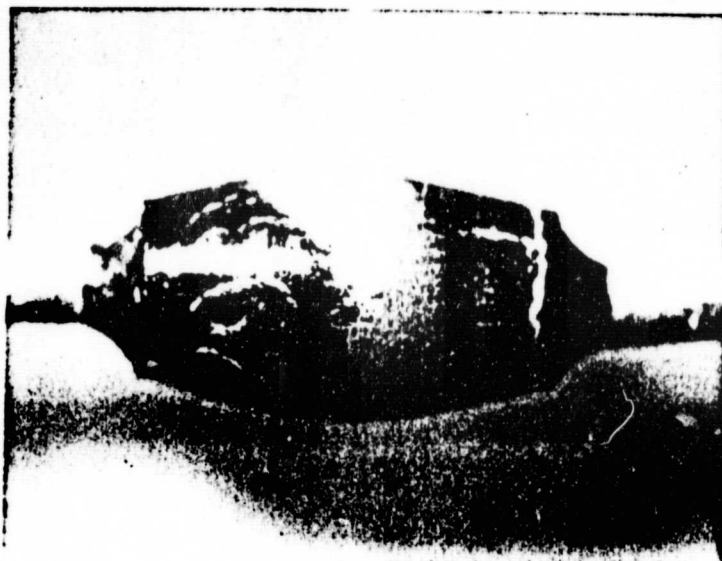


FIGURE A-1

S/N 6417, Typical Semtech Diode, 13X.

The white ring results from the removal of paint to test the sample without the leakage caused by the paint.

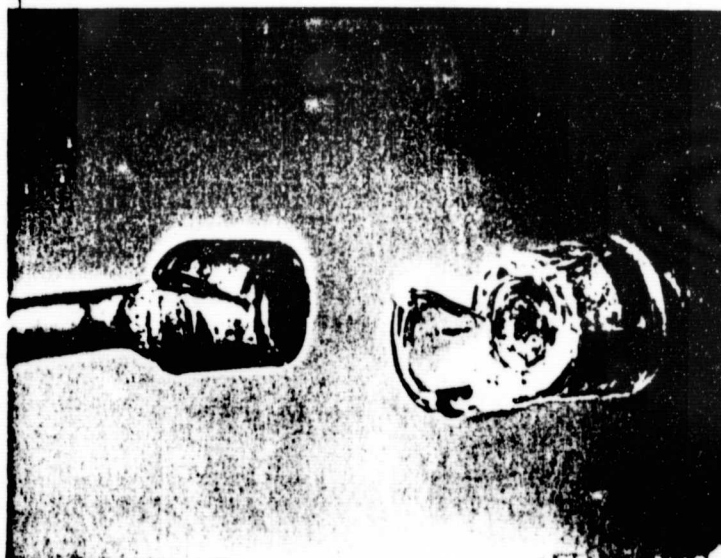


FIGURE A-2

S/N 6443, Micro Semiconductor Diode, 10X.

The existing cracks propagated during normal handling and the diode fell apart.

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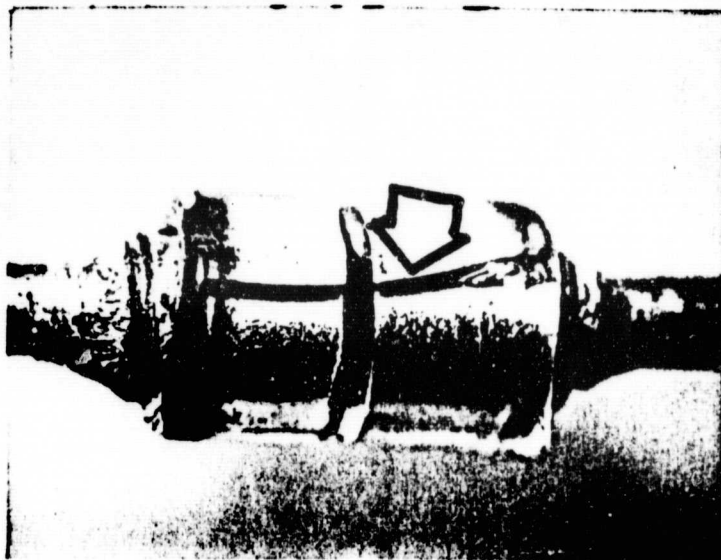


FIGURE A-3
S/N 6449, Typical Micro Semiconductor Sample
Showing Cracked Glass. 15X.



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APPENDIX B

FAILURE ANALYSIS

TEMPERATURE STRESS I



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FAILURE ANALYSIS

Date 18 December 1978

J/N 2CN242-26B P/N 1N5622 MFR SEMTECH

Cat. Limit:
50 μ A Max.Cat. Limits:
0.4-1.95V

S/N	PIV -volts-	I_R @ 1000 V.dc	V_F @ 3.0 A dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
6421 Paint off:	R 1100	>2.0mA <100nA	1.24	09 (150 $^{\circ}$ C 640 Hrs.)	I_R
6423 Paint off:	1100 R 1100	80 μ A 100nA	1.24	07 (125 $^{\circ}$ C 480 Hrs.)	I_R
6425 Paint off:	1100 R 1100	630 μ A 100nA	1.20	07 (125 $^{\circ}$ C 480 Hrs.)	I_R

VISUAL INSPECTION

There were no visual defects on these Semtech samples other than a slight darkening of the external leads (see Figure B-1).

* h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
** h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable



JANTX1N5622

FAILURE ANALYSIS

Date 18 December 1978

J/N 2CN242-26B P/N 1N5622 MFR MICRO SEMICONDUCTOR

Cat. Limit:
50 μ A Max.Cat. Limits:
0.4-1.95 V

S/N	PIV -volts0	I_R @ 1000 V.dc	V_F @ 3.0 A dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
6463	1100	10 μ A	---	11 (175 $^{\circ}$ C 800 Hrs.)	Lead off
6468	---	---	---	09 (150 $^{\circ}$ C 640 Hrs.)	Broken glass and die.
6470	---	---	---	09 (150 $^{\circ}$ C 640 Hrs.)	Broken glass and die.

VISUAL INSPECTION

S/N 6468 came apart at the cathode external connecting metal joint. S/N 6468 and 6470 have broken glass, and their semiconductor dice have split leaving a portion on each heat sink (see Figure B-2).

* h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
** h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable



FIGURE B-1
S/N 6425, Typical Semtech Diode After Scraping
Off a Band of External Paint, 11X.

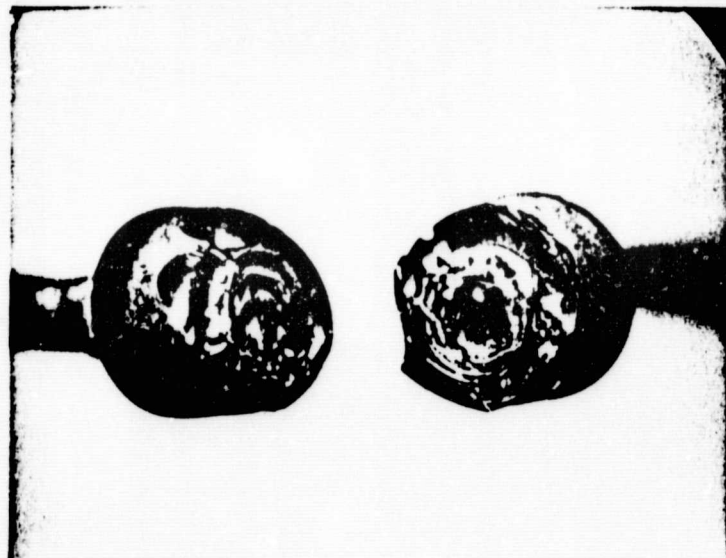


FIGURE B-2
S/N 6468, Typical Broken Glass and Die of
Micro Semiconductor Diodes, 13X.

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CONCLUSIONS

Semtech The Semtech diodes failed due to the development of excessive conductivity in the external paint. When this paint was removed in a band around the diode, the electrical measurements became acceptable, proving that the leakage was all in the paint.

Micro Semiconductor These diodes proved to be unable to resist the high temperature of the MSFC stress test. Failures resulted from melted metal on S/N 6463 and cracked glass due to excessive heat on S/N 6468 and 6470.



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APPENDIX C

FAILURE ANALYSIS

TEMPERATURE STRESS II



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FAILURE ANALYSIS

Date 4 May 1978

J/N 2CN242-26C P/N 1N5622 MFR SEMTECH

Max.
0.5 μ ALim. =
0.8 - 1.3 V

S/N taken from S/N 6429-34	PIV -volts-	I _R @ 1000 V.dc	V _F @ 3.0 A dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
01 *	shorted 1200	shorted (R) 100nA	1.16V ---	03	I _R , CAT
02 *	shorted 1280	shorted (R) 75 nA	1.24V ---	03	I _R , CAT
03 *	shorted 1380	shorted (R) 75 nA	1.20 ---	03	I _R , CAT

INTERNAL VISUAL INSPECTION

No visual anomalies were present. The paint and markings looked intact as the parts were received for analysis.

PAINT RESISTIVITY TEST

The external paint was tested across a diameter of the diode with an ohm meter, with the following results:

S/N	OHMS AS RECEIVED	OHMS AFTER PAINT REMOVAL
01	48K	>20 meg
02	36K	>20 meg
03	43K	>20 meg

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* These readings were taken after interrupting the paint conductive path.

*^hFE trace present. Cannot meet stated test conditions. (Leaky)
**^hFE trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable



JANTX1N5622

FAILURE ANALYSIS

Date 4 May 1978

J/N 2CN242-26C P/N 1N5622 MFR MICRO SEMICONDUCTOR

Max. = 0.5 μ A Lim.=0.8-1.3V

S/N	PIV -volts-	I_R @ 1000 V.dc	V_F @ 3.0 A dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
04*	9.0→210(uns)	>20 mA	1.24	10	I_R , CAT
6483	(R) 158	>20 mA	1.24	03	I_R , CAT
6488	broken - cannot measure			09	I_R , visual

INTERNAL VISUAL INSPECTION

S/N 04 and 6483 have cracked glass and S/N 6488 has broken glass (see Figures C-2 and C-3).

* S/N 04 taken from 6477, -84, -90

* h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
** h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

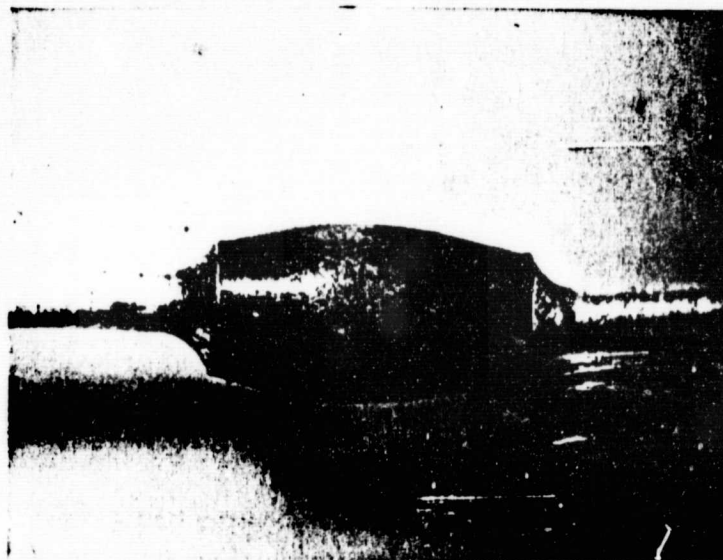


FIGURE C-1
S/N 02, Interruption of Paint Conductive
Path by Abrasive Paper, Semtech, 10X.

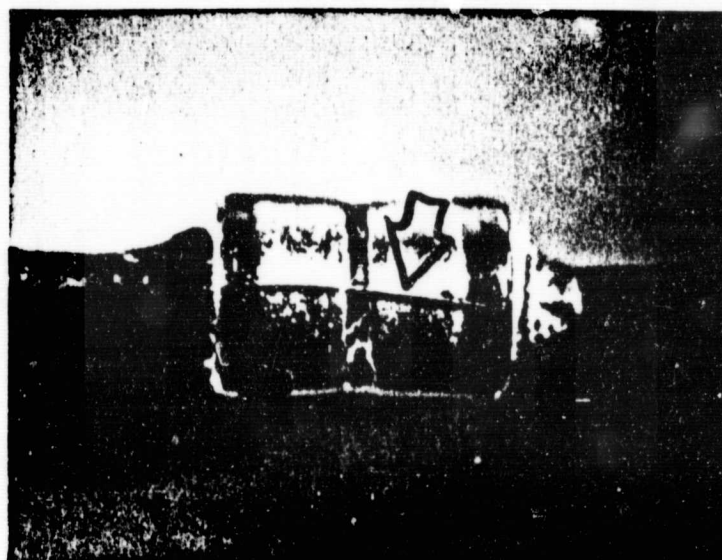


FIGURE C-2
S/N 04, Micro Semiconductor, 11X.
Arrow Indicates Cracked Glass.

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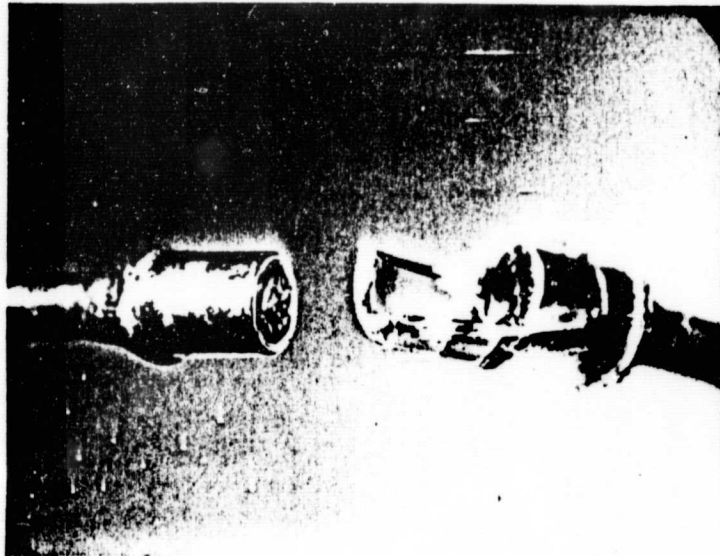


FIGURE C-3
S/N 6488, Semtech, 10X.
Broken glass and die.



CONCLUSIONS

Semtech These samples failed the reverse bias leakage test because of conductive external paint. When the continuity of the paint was interrupted by means of sandpaper the reverse leakages fell to acceptable levels (see Figure 1).

Micro Semiconductor Five of the sixteen samples of this subgroup have cracked or broken glass and one has a missing lead at the connecting metal joint. The loss of the lead is due to the low melting point of the bonding metal. The excessive glass breakage is due to residual glass strain which was not annealed out. The strain can be seen under polarized light.

In addition to the cracked glass, S/N 04 and 6483 have damaged junctions. S/N 04 has an initial breakdown at 9 volts and a second very unstable breakdown at 210 volts, which is reached at a current of 20mA. S/N 6483 has a breakdown of 158 volts, which is reached at 20mA. The curve trace is resistive throughout. Moisture entering through the cracked glass was eliminated as a cause of the leakage of S/N 6483 since at 125°C bake did not change the curve trace. Therefore, the damage must be considered as power induced. The same is true of S/N 04.